A Habitat Type Classification System for Ponderosa Pine Forests of Northern Arizona

Jess P. Hanks, E. Lee Fitzhugh, and Sharon R. Hanks

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Abstract

Four major habitat types (HT's), divided into 12 phases (P's), are described for the ponderosa pine forests of northern Arizona. In addition, five community types (CT's) are described for the same area. On a wet to dry gradient, the HT's are (1) *Pinus ponderosa/Muhlenbergia virescens*, (2) *Pinus ponderosa/Muhlenbergia virescens-Festuca arizonica*, (3) *Pinus ponderosa/Festuca arizonica*, and (4) *Pinus ponderosa/Bouteloua gracilis*.

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A Habitat Type Classification System for Ponderosa Pine Forests of Northern Arizona[1]

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Contents

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INTRODUCTION

Classification of ponderosa pine (*Pinus ponderosa scopulorum*) forests into habitat types can help improve understanding of the ecology of forested lands in the Southwest.

The study objective was to develop a classification and a key to identify the potential of land to support plant associations in ponderosa pine forests in northern Arizona. Ecotones between ponderosa pine, mixed conifer, and pinyon-juniper forests were sampled to provide a transition with Moir and Ludwig's (1979) classification of spruce-fir and mixed conifer forests in the same area, and with future work in pinyon-juniper areas.

The methodology was developed by Daubenmire and Daubenmire (1968) and modified by Franklin et al. (1970) and Pfister and Arno (1980). The classification can be used as the vegetation component of the "Modified Ecoclass" land classification system being developed by the USDA Forest Service (Buttery 1978).

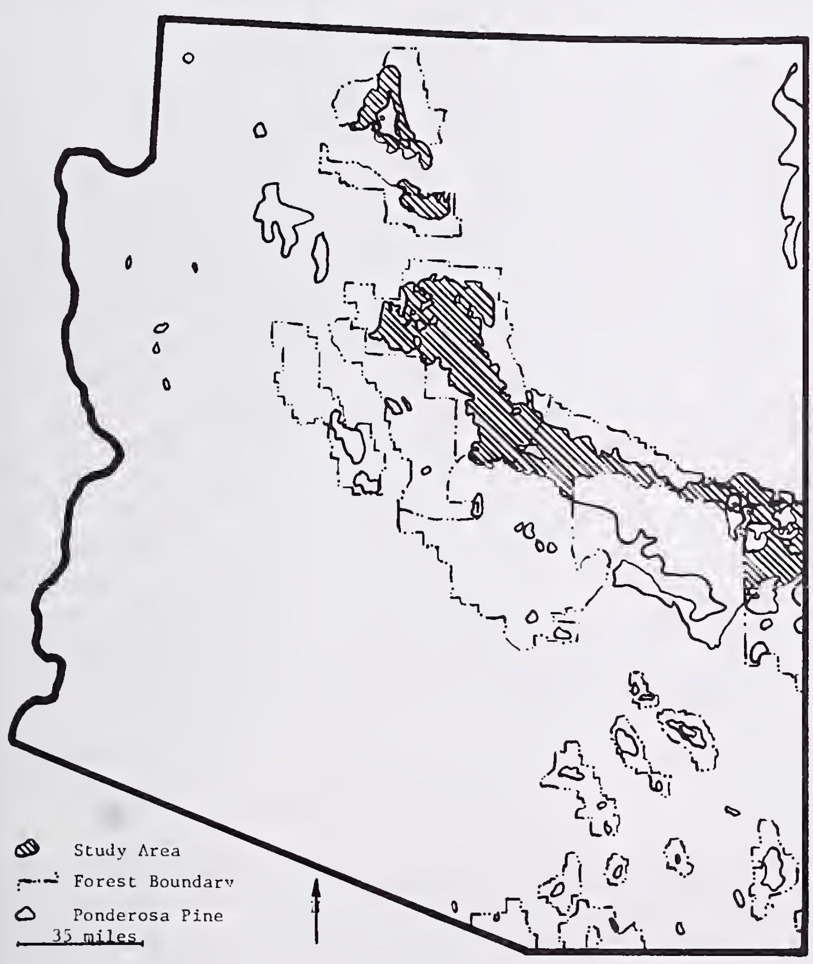

Figure 1.—Distribution of *Pinus ponderosa* in Arizona. The study area, which is diagonal-striped, is restricted to ponderosa pine forests on the Colorado Plateau.

STUDY AREA

The study area encompassed northern Arizona (fig. 1). Spencer (1966) indicated that there are 3.36 million acres of commercial ponderosa pine forest in Arizona, much of which is included in the study. Forests ranged from 33.5 to 36.5 degrees latitude and from 109 to 112.5 degrees longitude, with only two breaks in continuity at the northwest end. The Kaibab plateau, which is isolated from the remainder of the study area, is split into two parts by the Grand Canyon. The north rim of the Canyon contains more than 1,000 square miles of forest, much of which is ponderosa pine. It is one of the few block plateaus that is bounded on all sides by escarpments and slopes which descend to lower vegetation types (Rasmussen 1941). The influence of Great Basin vegetation and climate are pronounced on these two areas, leading one to expect different plant communities than elsewhere in the study area.

Elevation ranges from about 6,000 to 9,000 feet (1,830 m to 2,740 m). Soils are derived from igneous, alluvial, and sedimentary parent materials. Cold winters and cool summers are characteristic. Precipitation is nearly equally divided between snowfall from November through March and convective rainstorms during July and August. Rainfall tends to predominate in the southeast and snowfall in the northwest parts of the area. An apparent moisture gradient exists over the area, with the southeast being more moist and the northwest drier. However, the gradient may be related to available moisture, because it is more evident from plant communities than from the recorded precipitation; moisture is more evenly distributed throughout the year in the southeast, and soils are probably more fully developed.

The study area is a relatively level plateau, divided by steep-walled canyons and dotted by volcanic hills, of which the San Francisco Peaks in the northwest and Green's Peak and Mount Baldy in the southeast are the largest and extend above timberline. Wet areas surround these mountains and occur along the escarpment of the Mogollon Rim and in the high, southeastern part of the plateau. These areas support mixed conifer and spruce-fir vegetation.

METHODS

Terminology

Terminology is often misunderstood, primarily because different definitions have developed with time and different disciplines; therefore, the terms used in this study are defined.

Climax.—Tansley's (1935) polyclimax concept, with modifications explained below, has been adopted. He recognized the following climax types, without distinction as to their relative importance: climatic, edaphic, physiographic, biotic, and fire. In each case, climaxes are named after the factor causing them to differ from climatic climax. Daubenmire (1952) recognized Tansley's definition of climax, but ignored fire and zootic climaxes. This study followed recent precedent (Daubenmire and Daubenmire 1968, Pfister et al. 1977) in ignoring fire as a cause of "climax."

Effects of livestock were excluded in interpreting climax, but natural grazing by native herbivores was taken into account. Unlike Kuchler (1964), a distinction was made between wild and domestic herbivores because diet preferences of animals, the nature and intensities of grazing, and frequency of overgrazing affect vegetation differently.

Union.—A union is a group of plants which exhibit similar changes in local distribution because they have similar ecological limitations (Daubenmire 1952). Several unions often grow on one site, and together form a plant community.

Association.—An association (Daubenmire 1952) is a conceptual term describing actual stands which are environmentally and vegetationally similar, except for effects of historical or chance events. Daubenmire applies the term association only to climax communities. It is the basic unit of vegetation classification and is composed of all unions that are superimposed on the same area.

Habitat type.—Habitat type (Daubenmire 1952, Daubenmire and Daubenmire 1968, Pfister et al. 1977) is used to describe units of land which are capable of producing similar plant associations if undisturbed. Two land areas with obvious differences in measurable environmental factors may fall within the same habitat type, if they are equivalent with respect to plant requirements. For example, a habitat type can occur on two sites with different soils and climatic regimes when greater moisture holding capacity of soils on one site compensates for a drier climate. As long as compensating factors are considered, all habitat types should be distinct from all others in topographic position, nature of soil, hydrologic cycle, temperature relations, nutritive relations, etc. Plants should express differences in habitat through variation in such things as vegetative growth, resistance to disease, distinctive small animal and insect communities, and rate of recovery after disturbance.

Phase.—Phases are variations in climax habitat types which are less distinct than variations between habitat types. They may also represent areas which lack sufficiently detailed studies to allow quantification into habitat types. Such areas may not be included in the study areas because they are geographically or commercially insignificant; they may be represented in the study area as transitional communities more widely and typically found outside the study area. The term is also used to describe variants of habitat types which may be late, long-persistent seral stages. It was not possible to differentiate, in these latter situations, between late seral and climax communities. Because of their obvious persistence, however, any such distinction would have little meaning to resource managers.

Community type.—A community type refers to recurring vegetation where internal, ecological distinctiveness has not been demonstrated (Daubenmire 1976) or where climax state is uncertain (Hall 1973).

Temperature-moisture relationships.—The terms temperature-moisture or wet-dry are used for simplicity. Temperature and moisture often are the dominant factors affecting vegetation distribution in the study area, but the droughty characteristics of different soils and seasonal temperature patterns are included as major influences. Nutritive influences of different soils are both separate from, and influenced by moisture characteristics and are also intended to be a part of the temperature-moisture categories.

Elevation, topography and aspect, radiation, potential evapotranspiration, and local precipitation patterns belong with the moisture and temperature considerations. The term temperature-moisture category does not mean a simple radiation-precipitation function, but a complex of localized and sometimes compensatory factors, some of which may have more influence on plant growth through other means (e.g. nutrients) than strictly through moisture or temperature.

Grazing intensity.—The terms used to describe grazing influence should be interpreted in the context of the sampling of relatively undisturbed stands. Therefore, moderate and heavy grazing refer to a scale in which "heavy" indicates a stand where species composition has been obviously altered by grazing but not enough to exclude indicators of the original community. Heavy grazing would also represent a situation in which some invader plants were present and obvious, but in which the life-form of the community had not appreciably changed. Only in the Kaibab National Forest, and a few plots in the Coconino National Forest, where it was impossible to find better locations, were communities sampled in which the life-form (Arnold 1950) had been affected by grazing. Moderate grazing disturbance indicates a condition in which grazing influence is obvious in lower cover values for decreaser plants (Dyksterhuis 1949) and higher cover values for increaser plants, but without important changes in species composition of the community. Therefore, the stands sampled would, with the above-mentioned exceptions, be classed as good or excellent by Arnold's (1950) or most other range condition classifications.

Plant Identification

Nomenclature follows that of McDougall (1973) with two exceptions: (1) *Poa longiligula* was retained for longtongue mutton bluegrass, rather than a variant of *P. fendleriana* (mutton bluegrass), because *P. longiligula* is easily recognized by long ligules and appears to have indicator value in the ponderosa pine types; (2) Forest Service nomenclature has been fol-

lowed (Nickerson et al. 1976) for bottlebrush squirreltail, *Sitanion hystrix* even though McDougall (based on Wilson 1963) contended that *S. longifolium* has been misidentified in Arizona as *S. hystrix*.

Voucher specimens were sent to Charles Feddema, USDA Forest Service Herbarium Curator, Fort Collins, Colo., for verification and identification of questionable species. Collections were made of most plant species and are on file in Northern Arizona University's Deaver Herbarium.

Vegetation Indicator Species

No published information was available to identify plant species which might have value as indicators of habitat types. A chart, which was based on altitudinal ranges of some common species (Kearney et al. 1960) and modified by the authors' personal knowledge and experience, was developed to reflect moisture requirements. Richard H. Hevly and James M. Rominger of the Department of Biological Sciences, Northern Arizona University, suggested revisions. The revised chart, along with notes taken in the field, helped determine indicator species, plots that represented wet or dry extremes, and helped to check computer groupings for logical consistency.

Plant species were initially and subjectively identified as indicators of habitat types after a number of plots had been measured over a range of physical environments. It was then possible to recognize geographic limits of plant unions and relate these limits to environmental influences such as precipitation patterns, soil development, rockiness, and temperature gradients. In addition, the plant unions themselves were assumed to indicate the existence of environmental factors too complex for ready measurement. Thus, the plant unions were used as an indicator of habitat supported by records of physical factors. Individual plants in those unions were chosen as indicator plants for the unions. As unions were combined into habitat types, plant species were retained as diagnostic indicators of habitat type if they showed a high degree of ubiquity (constance) in one type and were not dominant, frequent, and constant in other types. Ubiquity was measured by the percentage of plots in a type which contained the species. In some cases, it was necessary to add an abundance factor (coverage) below which the plant was not considered to be an indicator of habitat type. The need for an abundance factor resulted from the tendency for dry habitat plants to invade moist sites after disturbance (Daubenmire 1976).

Identification of Potential Vegetation

Stands representing potential vegetation were identified by selection of undisturbed sites, as evidenced by lack of logging activity, distance from livestock water, and administrative or geographical isolation from livestock use. Undisturbed stands served as benchmarks for recognizing other minimally disturbed sites. However, while such stands were considered ideal, they were not always available. Unless stands met the criteria for minimally disturbed conditions, they were not sampled. Instead of random choice of disturbed sites, sampling was limited to stands where the degree of disturbance could be detected by indicator plants. Recognition of disturbance by plant indicators is a well-established method in the area studied (Arnold 1950, 1955; Bostick;[3] Clary and Pearson 1969; Hanson 1924; Talbot 1957), and is based on knowledge of retrogression caused by grazing, fire, or other disturbances.

After partial analysis of data, some communities with unclear ecological status were identified. Investigation of relict areas, range exclosures, and inquiries into past history of the sites were made to clarify ecological status. These investigations became more difficult with progression into drier, more fragile and/or more heavily used areas in the northwest. Further, because of disturbance, it was not possible to relate some communities in the Kaibab National Forest to potential vegetation. Consequently, such unknown entities have been termed community types rather than habitat types.

Sample Plots

A circular, 0.1-acre (375 m^2) reconnaissance plot was used for visual estimates of plant cover values. A 49.2-foot (15 m) by 82-foot (25 m), rectangular, analytical plot (Daubenmire and Daubenmire 1968), subsampled with square foot (1 dm) rectangular quadrats, was used to reduce bias in visual estimates of cover.

Analytical plots were used in areas which appeared to be highly representative of a plant association. An effort was also made to intersperse analytical plots with reconnaissance plots in order to provide a check and to continually improve the ability to make accurate visual estimates of cover values.

Species presence was recorded outside plots, as long as the plant community and ecological influences where plants were found were homogeneous with the plot. Therefore, plant frequency data reflect a far larger plot size, approaching a sampling of about 1 acre (0.4 ha) unless lack of homogeneity restricted the available area.

Sampling Procedure

Because 331 plots were sampled throughout northern Arizona, small sample size, coupled with the need to obtain plots representative of potential vegetation, required a subjective sampling method. While the USDA Forest Service and the National Park Service helped to identify areas inaccessible to livestock, allotments in good range condition, and near-virgin timber

[3]"Principles for judging condition and trend of southwestern woodland ranges," an unpublished report prepared by Vernon B. Bostick for the Southwestern Region of the Forest Service, 1947.

stands, most areas were found by personal inspection of stands. Areas were inspected where topography, proximity to water, and presence of fences indicated low cattle density and disturbance. If suitable, these areas were used in sampling.

Specific plot locations were chosen subjectively to eliminate heterogeneity caused by disturbance or ecological changes and to more effectively sample a full range of environmental factors.

The extremely clumped nature of mature pine forests was sampled in one of two ways: by placing two paired plots adjacent to each other, one in the open and one under the trees; or by placing one plot partly in each area.

Deliberate attempts were made to obtain plots that represented the extreme limits of each community studied. An effort also was made to obtain uniform coverage of the study area by reviewing plot locations after most of the data were collected, then locating plots in areas formerly unsampled. Intentional clustering of plots occurred when areas (1) contained several different communities within a short distance, (2) represented ideally undisturbed conditions, or (3) exhibited extremes of slope and topography within a short distance.

Types of Data Recorded

Parent material, landform, position in the landscape, elevation, slope, aspect, surface stoniness and rockiness, percent of exposed mineral soil, and vascular plant basal area were recorded for each plot. Soil series and types were obtained from soil maps when they were available.

Within the plots, tree species and diameters at breast height (d.b.h.)—4.5 feet (1.36 m)—were recorded. Tree reproduction (trees shorter than 4.5 feet) was counted. In most northern Arizona plant communities, Gambel oak (*Quercus gambelii*) grows to tree form. In the present study, clusters of oak reproduction or sprouts were classed as shrub cover. Tree form Gambel oak was identified whenever a measurable stem existed at breast height. Shrub cover excludes coverage of tree form oaks. Understory canopy cover in plots was recorded by species, using the following cover classes in analytical plots:

- 0.02 = plant present outside the plot.
- 0.1 = plant present inside boundaries of a plot, but not abundant enough to be sampled in the quadrats of an analytical plot.
- 0.9 = plant present in the plot with less than 1% coverage. It would normally be sampled in the quadrats of an analytical plot.
- 1.0 = 1% canopy cover. Plants would be sampled in an analytical plot.
- 2.0 = 1 to 5% canopy cover.
- 3.0 = 5 to 25% canopy cover.
- 4.0 = 25 to 50% canopy cover.
- 5.0 = 50 to 75% canopy cover.
- 6.0 = 75 to 95% canopy cover.
- 7.0 = 95 to 100% canopy cover.

For simplicity, actual percentages instead of class codes were recorded for coverages of 1% or more in reconnaissance plots. The same class codes were used for coverages of less than 1%.

Comments were recorded regarding fire history, logging, grazing, mistletoe, canopy cover, extent of stand, and adjacent communities. Two color photographs were taken of each plot.

Analysis of Data

Data were analyzed in four broad steps: (1) initial subjective analysis, (2) computer-assisted analysis used together with subjective evaluation, (3) review by others familiar with the area and with habitat type classification, (4) modification with further analysis where indicated. The analytical method used here is more completely described below and by Franklin et al. (1970) and Pfister and Arno (1980). Mueller-Dombois and Ellenberg (1974) describe and evaluate the methods used.

Initial analysis.—After the first summer of field work, 29 species or pair of species believed to be indicators of the different ecological conditions were chosen. Parent material was added to the list, and an association table was made, by plot, for the 196 plots completed that summer. Plots were arranged to place them in discrete groups based on different moisture-temperature regimes sampled. Subjective impressions of moisture-temperature regimes were based on precipitation patterns known (Jameson 1969) or surmised from local topography and climatic patterns. Soils, aspect, slope, and plant indicators also helped to determine moisture-temperature categories for plots. The classification thus formed was used in the initial stages of computerized ordinations (Mueller-Dombois and Ellenberg 1974) to test the logic of groupings.

Computer analysis.—Ordination analysis is a technique that is useful to assess similarities and differences among sets of vegetation data. Whittaker (1973) has provided an in-depth analysis of the application of ordination analysis in classification of plant communities. Procedures and strategies for using ordinations and computer programs to implement them, produced by Gauch (1973), were used in this study. Polar (Bray-Curtis) ordination (Gauch 1973) was used in an iterative process, refining and changing initial groupings on the basis of all data available.

Field work during the second summer provided an opportunity to fill in gaps in the data, increase sample size, and obtain samples in new areas. The entire data base was then reanalyzed, using the same methods, to give a habitat type classification.

RESULTS

The habitat types identified appear in table A1. Association tables for selected species occurring in the habitat and community types appear in table A2.

The following field key may be used to identify sites which represent the habitat types, community types, and phases in the ponderosa pine forests of northern Arizona.

To use this key effectively, these guidelines must be followed:

1. Ponderosa pine should be the actual or potential dominant canopy tree. Stands containing more than minor amounts (5-10 stems per acre more than 4 inches d.b.h.) of white fir (*Abies concolor*) or southwestern white pine (*Pinus strobiformis*), or more than 15 stems per acre of Douglas-fir (*Psuedotsuga menzeisii*) should be classified using Moir and Ludwig's (1979) key.
2. A stand should be selected that has the least amount of disturbance. If it is severely disturbed, the habitat type, phase, or community type can best be determined by extrapolating from adjacent stands occupying similar sites.
3. The stand should be examined carefully to determine species composition by canopy cover, because diagnostic species can have low densities or cover in some circumstances.
4. After the stand has been keyed, it should be carefully compared with the group description and association table (table A2) to determine if it fits the description.

Field Key

1a. *Arctostaphylos pungens*, *Quercus turbinella*, or *Quercus arizonica* present —— *Pinus ponderosa/ Arctostaphylos pungens* CT
1b. All of the above plants absent —— 2
2a. *Muhlenbergia virescens* present (*M. montana* is similar in appearance; check identification carefully) —— 3
2b. *Muhlenbergia virescens* absent —— 7
3a. *Festuca arizonica* present —— 4
3b. *Festuca arizonica* absent —— 6
4a. *Bouteloua gracilis* present —— *Pinus ponderosa/ Muhlenbergia virescens-Festuca arizonica-Bouteloua gracilis* CT
4b. *Bouteloua gracilis* absent —— 5
5a. *Quercus gambelii* common (**) —— *Pinus ponderosa/ Muhlenbergia virescens-Festuca arizonica* HT, *Quercus gambelii* P
5b. *Q. gambelii* minimal/ absent (**) —— *Pinus ponderosa/ Muhlenbergia virescens-Festuca arizonica* HT, *Muhlenbergia virescens-Festuca arizonica* P
6a. *Quercus gambelii* common (**) —— *Pinus ponderosa/ Muhlenbergia virescens* HT, *Quercus gambelii* P
6b. *Quercus gambelii* minimal/absent (**) — *Pinus ponderosa/ Muhlenbergia virescens* HT, *Muhlenbergia virescens* P
7a. *Festuca arizonica* present —— 8
7b. *F. arizonica* absent —— 10
8a. *Bouteloua gracilis* present with more than 1% coverage —— *Pinus ponderosa/Festuca arizonica* HT, *Bouteloua gracilis* P
8b. *B. gracilis* absent or present with less than 1% coverage —— 9
9a. *Quercus gambelii* common (**) —— *Pinus ponderosa/Festuca arizonica* HT, *Quercus gambelii* P
9b. *Q. gambelii* minimal/absent (**) —— *Pinus ponderosa/Festuca arizonica* HT, *Festuca arizonica* P
10a. *Bouteloua gracilis* present —— 12
10b. *B. gracilis* absent —— 11
11a. Stand located on the north rim of the Grand Canyon —— *Pinus ponderosa/Poa longiligula* CT
11b. Stand located elsewhere in northern Arizona —— *Pinus ponderosa/Poa fendleriana* CT
12a. *Artemisia tridentata* present —— *Pinus ponderosa/Bouteloua gracilis* HT, *Artemisia tridentata* P
12b. *A. tridentata* absent —— 13
13a. Parent material composed of fine cinders; stand occurring in cinder hills area northeast of Flagstaff, Arizona —— *Pinus ponderosa/Bouteloua gracilis* HT, *Andropogon hallii* P
13b. Parent material and location otherwise —— 14
14a. *Cowania mexicana* present with more than 2% coverage —— *Pinus ponderosa/Cowania mexicana* CT
14b. *C. mexicana* absent or with less than 2% coverage —— 15
15a. *Pinus edulis* present —— *Pinus ponderosa/Bouteloua gracilis* HT, *Pinus edulis* P
15b. *P. edulis* absent —— 16
16a. *Quercus gambelii* common (**) —— *Pinus ponderosa/Bouteloua gracilis* HT, *Quercus gambelii* P
16b. *Q. gambelii* minimal/absent (**) —— *Pinus ponderosa/Bouteloua gracilis* HT, *Bouteloua gracilis* P

(**) Gambel oak is considered common if there are more than 5 trees per acre or if its shrub cover is more than 1%. It is considered minimal if there are fewer than 5 tree stems per acre and its coverage as a shrub is less than 1%.

General Characteristics of the Types

The key identifies 4 ponderosa pine habitat types, 12 phases, and 5 community types. Relative amplitudes of major diagnostic species, and distribution of the habitat types, phases, and community types on a mesic to xeric environmental gradient, are presented in figure 2.

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                              ENVIRONMENTAL GRADIENT
           ------------------------------------------------------------------
           |  warm-dry                                              cool-wet |
           |<--------------------------------------------------------------->|
           |                                                                 |
           |<------------------------- PIPO--------------------------------->|
SPECIES    |<------------------------- QUGA--------------------------------->|
AMPLITUDE  |                                        <--------MUVI---------->|
           |                         <------------FEAR-------->              |
           |<--------BOGR---------------->                                   |
           |<------PIED-------->                                             |
           |        <-ANHA->                                                 |
           |<--ARTR-->                                                       |
           |-----------------------------------------------------------------|
HABITAT     |          PIPO/BOGR          |   PIPO/FEAR   |PIPO/MUVI-|PIPO/MUVI|
TYPE        |                             |               |   FEAR   |         |
            |                             |               |          |         |
PHASE       |PIED|ARTR|ANHA|QUGA|BOGR|BOGR|QUGA|FEAR|QUGA|MUVI-|QUGA|MUVI|
            |    |    |    |    |    |    |    |    |    |FEAR |    |    |
            |____|____|____|____|____|____|____|____|____|_____|____|____|
COMMUNITY   |                   |COME|POFE|POLO|ARPU|MUVI-|                |
TYPE        |                   |    |    |    |    |FEAR-|                |
            |                   |    |    |    |    |BOGR |                |
            |___________________|____|____|____|____|_____|________________|
```

Figure 2.—Schematic distribution of trees and diagnostic understory species on a warm-dry to cool-wet environmental gradient. The distribution of the habitat types, phases, and community types is also shown on the same environmental gradient. The abbreviations used for the species are as follows: ANHA-*Andropogon hallii*, ARPU-*Arctostaphylos pungens*, ARTR-*Artemesia tridentata*, BOGR-*Bouteloua gracilis*, COME-*Cowania mexicana*, FEAR-*Festuca arizonica*, MUVI-*Muhlenbergia virescens*, PIED-*Pinus edulis*, PIPO-*Pinus ponderosa*, POFE-*Poa fendleriana*, POLO-*Poa longiligula*, QUGA-*Quercus gambelii*. QUGA, BOGR, PIED, and ARTR may have broader limits given significant disturbance conditions.

Mesic types are typically in areas of higher annual and summer precipitation, orographic uplift, higher elevations, northeasterly aspects, gentle slopes, cooler summer temperatures, shorter summer droughts, and deeper loamy soils. Xeric types have opposite characteristics, with soils tending to be very fine or very coarse.

Phases within each habitat type are based on significant variations in shrub and/or herb layers. Each habitat type has a Gambel oak (*Quercus gambelii*) phase which represents persistent late seral (climax on some sites) stands with significantly different vegetation, resource potential, and management implications.

Such stands are classed as phases rather than community types, because Gambel oak forms a persistent stage near equilibrium with other plants. In many areas of the Southwest, Gambel oak is clearly a successional species, although it may persist for more than 150 years after a disturbance such as fire. On some sites, such as ridge and mountain summits, it can be a component of a climax community (Hanks and Dick-Peddie 1974). On the Colorado Plateau, Gambel oak is sometimes successional, but usually occupies an uncertain niche. For example, Gambel oak phases appear to be self-perpetuating members of the climax community under natural tree spacing, perhaps involving fire ecology. While dense pine spacing often results from fire protection, Gambel oak tends to disappear after the large, old oak trees die. Gambel oak stands are very near climax and persistent in most situations and, consequently, have been classed as phases of habitat types.

It appears that continuing work in New Mexico may result in a ponderosa pine/Gambel oak habitat type.[4] If so, that type is ecologically distinct from the Gambel oak phases of these habitat types and should not be confused with them.

HABITAT TYPE DESCRIPTIONS

1. *Pinus ponderosa/Muhlenbergia virescens* (ponderosa pine/screwleaf muhly) habitat type

This type is the wettest ponderosa pine habitat type found in the study and is transitional to mixed conifer forests in many areas. The habitat type occurs in two phases, *Muhlenbergia virescens* and *Quercus gambelii*.

a. *Muhlenbergia virescens* phase (ponderosa pine/screwleaf muhly HT, screwleaf muhly P)

Distribution

The screwleaf muhly phase (fig. 3) occurs in the Apache-Sitgreaves National Forest and the south half

Figure 3.—Ponderosa pine/screwleaf muhly HT, screwleaf muhly P (plot 80), Wildcat Point, Apache National Forest, 7,640 feet (2,330 m) elevation. Dense, old growth stands support a variety of forbs and less screwleaf muhly.

[4]*Personal communication with John A. Ludwig, New Mexico State University, Las Cruces; and William Moir, now with the USDA Forest Service, Southwestern Region, Albuquerque, N. Mex., 1980.*

of the Coconino National Forest. It is found near the Mogollon Rim, at elevations ranging from 6,700 to 8,100 feet (2,040 to 2,470 m), on basalt, sandstone, limestone, and alluvial parent materials. More than 65% of the sites sampled were on rolling plateaus and gentle canyon sides with south and west exposures.

Soils have a loamy texture, and plots were in the Sponseller, McVickers, Soldier, and Wildcat soil series. Relatively deep litter and humus layers are typical.

Vegetation

Ponderosa pine is well represented in all size classes. The mean basal area for ponderosa pine is 87 square feet per acre (19.5 m² per ha), which is relatively high for habitat types reported in this study and for Arizona pine forests in general (Clary 1975, Ffolliott and Solomon 1976). Ponderosa pine reproduction (trees shorter than 4.5 feet, or 1.37 m, tall) averaged 220 stems per acre (544 per ha). Small trees of white fir, southwestern white pine, and Douglas-fir are occasionally found in this phase, but are never a component of the climax canopy and are always "accidental" (fewer than 5-10 stems per acre, or 12-25 per ha). When these trees are present in greater numbers, stands should be classified as mixed conifer habitat types (Moir and Ludwig 1979). Shrubs are a minor component in the screwleaf muhly phase of the ponderosa pine/screwleaf muhly HT. Screwleaf muhly is the dominant climax herbaceous species, with a mean cover of 16% (maximum 80%). Other common herbaceous species include groundsel (*Senecio wootonii*), pine dropseed (*Blepharoneuron tricholepis*), pseudocymopterus (*Psuedocymopterus montanus*), and sedge (*Carex* spp.).

Discussion

Fires occur with moderate frequency in this phase; most stands showed some evidence of past fires, but few showed signs of extensive crown fires. Most stands showed evidence of past logging, but it was mostly old activity and relatively light compared to other habitat types. Grazing was light to moderate in 80% of the stands. Mistletoe damage was light to moderate in 77%.

If the stand density of ponderosa pine is allowed to increase in this phase, shrub and herbaceous vegetation will probably decrease. In contrast, reducing stand density could not only increase herbaceous vegetation, but might also increase Gambel oak in the shrub layer.

b. *Quercus gambelii* phase (ponderosa pine/ screwleaf muhly HT, Gambel oak P)

Distribution

The Gambel oak phase (fig. 4) is more common than the screwleaf muhly phase of this habitat type. It occurs in the north half of the Coconino National Forest between Oak Creek Canyon and Sycamore Canyon, in the south half of the Coconino National Forest, and in the Apache-Sitgreaves National Forest. In these areas, it is near the Mogollon Rim and occurs at elevations between 6,700 to 8,500 feet (2,040 to 2,590 m). At lower elevations, this phase occurs on sandstone, limestone, and alluvial parent materials. On higher locations it is found on basalt, cinder, and conglomerate parent materials. More than 65% of sites sampled were on gentle canyon slopes and rolling plateaus with south and east exposures.

Figure 4.—Ponderosa pine/screwleaf muhly HT, Gambel oak P (plot 122), Barney Pasture, Coconino National Forest, 6,820 feet (2,079 m) elevation. White fir and Douglas-fir occur in small drainages and on gentle north slopes, showing the mesic nature of this type.

Soils in the ponderosa pine/screwleaf muhly HT, Gambel oak phase, are usually fine sandy loams, with finer textured soils occurring occasionally. More than 65% of the soils occurred in the Overgaard, Sponseller, Brolliar, and McVickers soil series, but more than 15 soil types are associated with this phase. Humus and litter layers are developed to a lesser extent than under the screwleaf muhly phase, but still more than most habitat types.

This phase contacts the same communities as the screwleaf muhly phase of the ponderosa pine/ screwleaf muhly HT. Northerly exposures support mixed conifer stands, while southwest exposures support

phases of the ponderosa pine/screwleaf muhly-Arizona fescue HT, ponderosa pine/Arizona fescue HT, or ponderosa pine/mutton bluegrass CT. On one site, a distinct change in parent material occurred, with limestone supporting a ponderosa pine/screwleaf muhly HT, Gambel oak phase and basalt soil supporting a ponderosa pine/mutton bluegrass CT.

Vegetation

The mean basal area of ponderosa pine was 91.1 square feet per acre (20.9 m^2 per ha), the third highest recorded for phases in this study. Ponderosa pine reproduction averaged 126 stems per acre (311 per ha). Gambel oak is present as a tree (1 inch d.b.h. or greater) in more than 80% of these stands. In stands lacking oaks of tree size, shrub cover of oak averages 5% and is always more than 1%. Mixed conifer tree species are occasionally present in very limited amounts in this phase. Screwleaf muhly averages 4% cover, with maximum coverage values of 25%. Increased competition for light and moisture with Gambel oak in this phase reduces herbaceous coverage.

Discussion

Fires have occurred with moderate frequency in the Gambel oak phase, and most fire damage was more than 20 years old. A few stands showed signs of serious crown fires, but plots were excluded from these areas. Succession after an early spring wildfire of varying intensity was reported for this phase by Fitzhugh and Beaulieu.[5]

Logging occurred in most areas, with subsequent varying degrees of thinning. Grazing and mistletoe infection were light to moderate in 70% of the stands. Grazing capacity has been reduced during the past 50 years in this phase because of fire protection and the encroachment of dense pine sapling thickets. The presence of dense oak thickets reduces the potential for livestock carrying capacity, although it is still high compared to most ponderosa pine habitat types.

Gambel oak should be considered a persistent species in late successional stages. It may increase if pine competition is removed. The importance of this type in providing browse, dens, and mast may be considerable, and can be enhanced by practices that induce oak sprouting and retain older trees which serve as dens for small mammals and birds. This phase could develop very slowly into the screwleaf muhly phase, but over such a long time span to be impractical for management to enhance such development.

Any disturbance to the site in this phase may result in increased densities of Gambel oak and New Mexican locust (*Robinia neomexicana*). Species easily established by seeding after site disturbance include intermediate wheatgrass (*Agropyron intermedium*), orchardgrass (*Dactylis glomerata*), bromes (*Bromus* spp.), and sweetclover (*Melilotus* spp.).

[5]*Final report "Wildlife effects on plant and animal communities in Arizona ponderosa pine forests," by E. Lee Fitzhugh and Jean T. Beaulieu, 1975, for cooperative agreement 16-454-CA, Rocky Mountain Forest and Range Experiment Station. The Station's headquarters is in Fort Collins, in cooperation with, Colorado State University.*

2. *Pinus ponderosa/Muhlenbergia virescens-Festuca arizonica* (ponderosa pine/screwleaf muhly-Arizona fescue) habitat type

This is a moderately mesic ponderosa pine habitat type in which screwleaf muhly and Arizona fescue are codominants in the herb layer. Pseudocymopterus and sedge are common. The habitat type occurs in two phases. Additionally, the ponderosa pine/screwleaf muhly-Arizona fescue-blue grama community type, described later, is a secondary successional stage in this habitat type.

a. *Muhlenbergia virescens-Festuca arizonica* phase (ponderosa pine/screwleaf muhly-Arizona fescue HT, screwleaf muhly-Arizona fescue P)

Distribution

This phase (fig. 5) is common in the Apache-Sitgreaves National Forest and adjacent areas in the southern Coconino National Forest and is found occasionally in the San Francisco Peaks area near Flagstaff, Ariz. It is usually further north of the Mogollon Rim on drier sites than either phase of the ponderosa pine/screwleaf muhly habitat type and occurs at elevations ranging from 6,900 to 9,200 feet (2,100 to 2,804 m). At higher elevations, the phase is usually found on exposed ridges and escarpment edges with basalt parent materials, while lower elevation sites occupy sandstone and limestone parent materials.

Figure 5.—Ponderosa pine/screwleaf muhly-Arizona fescue HT, screwleaf muhly-Arizona fescue P (plot 85), Middle Mountain, Apache National Forest, 8,480 feet (2,585 m) elevation. This type is highly productive of both timber and forage, but regression is easily induced in the plant community.

More than 80% of the soils were sandy or silty loams and occurred in the McVickers, Sponseller, Soldier, and Hogg soil series.

The phase is found on moist sites in climax ponderosa pine types. In wetter areas, it is adjacent to the ponderosa pine/screwleaf muhly HT or to mixed conifer stands dominated by white fir and Douglas-fir, with Arizona fescue, screwleaf muhly, and mountain muhly (*Muhlenbergia montana*) as herbaceous dominants. The screwleaf muhly-Arizona fescue phase occurs in contact with the ponderosa pine/Arizona fescue HT on drier sites.

Vegetation

Ponderosa pine is the dominant canopy tree and reaches its highest basal area (94.4 square feet per acre; 21.7 m² per ha) in this phase. Ponderosa pine reproduction averaged 240 stems per acre (593 per ha). Screwleaf muhly averaged 8% cover, with maximum values of 40%; Arizona fescue averaged 11% cover, with maximum cover values of 55%.

Discussion

Logging has been generally light, but some stands have been heavily cut in recent years. Grazing has been light to moderate in this phase. Mistletoe occurs at light, moderate, and heavy levels with nearly equal frequencies. This phase produces some of the best timber and forage among the ponderosa pine habitat types.

b. *Quercus gambelii* phase (ponderosa pine/screwleaf muhly-Arizona fescue HT, Gambel oak P)

Distribution

The Gambel oak phase of the ponderosa pine/screwleaf muhly-Arizona fescue HT (fig. 6) occurs in the same geographic areas and elevational ranges as the screwleaf muhly-Arizona fescue phase. It is found on limestone, sandstone, and basalt parent materials with equal frequency. The phase occurs more frequently on steep canyon slopes which vary more in exposure than sites supporting the screwleaf muhly-Arizona fescue phase. The Gambel oak phase occurs on more than nine soil series and is characterized by rockier soils than the screwleaf muhly-Arizona fescue phase.

Vegetation

Ponderosa pine basal area was 85 square feet per acre (19.7 m² per ha), and ponderosa pine reproduction averaged 240 stems per acre (593 per ha). Gambel oak is common as a tree and a shrub. Both screwleaf muhly and Arizona fescue have substantially lower average cover values (4% and 2%, respectively) than in the screwleaf muhly-Arizona fescue phase. Arizona fescue, because of its lower shade tolerance, shows a much larger cover reduction than screwleaf muhly.

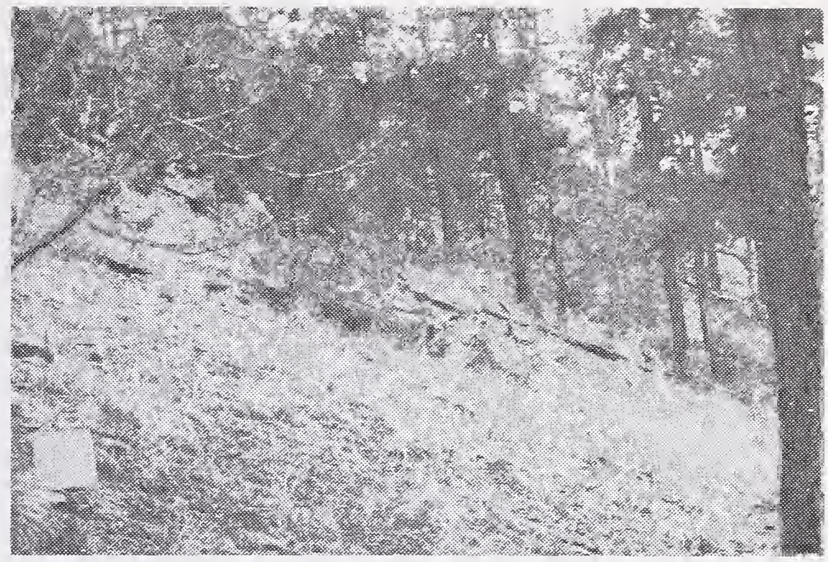

Figure 6.—Ponderosa pine/screwleaf muhly-Arizona fescue HT, Gambel oak P (plot 96), Stone Creek near Thomas Creek, Apache National Forest, 8,000 feet (2,438 m) elevation. This phase of the HT is less productive, occurs on steeper, rockier areas, and has greater wildlife value than the screwleaf muhly-Arizona fescue phase.

Discussion

The Gambel oak phase of the ponderosa pine/screwleaf muhly-Arizona fescue HT represents a very persistent late seral stage which would return slowly, if at all, to the screwleaf muhly-Arizona fescue phase. The Gambel oak phase contacts the same communities as the screwleaf muhly-Arizona fescue phase.

Fires were more common and destructive in this phase of the habitat type than in the associated phase. Light to moderate amounts of mistletoe were found. This phase is probably less suitable for livestock use than the screwleaf muhly-Arizona fescue phase, because of reduced forage, steeper terrain, and erosion susceptibility. The Gambel oak phase is more diverse and, therefore, more valuable to wildlife than the screwleaf muhly-Arizona fescue phase.

3. *Pinus ponderosa/Festuca arizonica* (ponderosa pine/Arizona fescue) habitat type

The ponderosa pine/Arizona fescue HT is an intermediate (relative to xeric or mesic) climax ponderosa pine forest type. It occurs in three phases: *Festuca arizonica*, *Quercus gambelii*, and *Bouteloua gracilis*.

a. *Festuca arizonica* phase (ponderosa pine/Arizona fescue HT, Arizona fescue P)

Distribution

The Arizona fescue phase (fig. 7) is centered in the Coconino National Forest in the vicinity of Flagstaff,

Figure 7.—Ponderosa pine/Arizona fescue HT, Arizona fescue P (plot 152), south of Kendrick Park, Coconino National Forest, 8,010 feet (2,441 m) elevation. This habitat type and phase is common near Flagstaff, Ariz., and is subject to rare episodic regeneration under natural conditions.

Ariz. It occurs occasionally in the Apache-Sitgreaves and in the southern part of the Kaibab National Forests. It ranges in elevation from 6,800 to 9,200 feet (2,070 to 2,800 m), and is most common on basalt parent material, although it occurs on sandstone and limestone. The phase is found on essentially flat areas of less than 10% slope in the majority of situations, although stands can occur on slopes greater than 40%. The phase occurs on more than 10 soil series, of which Brolliar soils are the most common.

The Arizona fescue phase is a climax type, and occurs in contact with mixed conifer stands dominated by white fir, Douglas-fir, and Arizona fescue (Moir and Ludwig 1979). Among ponderosa pine forests on wetter sites, it is adjacent to the ponderosa pine/screwleaf muhly-Arizona fescue habitat type, and on drier sites, the ponderosa pine/blue grama HT. Where vertisol soils occur adjacent to the Arizona fescue phase, they may support a ponderosa pine/blue grama type. The Arizona fescue phase on vertisol soils may be converted easily to a ponderosa pine/blue grama plant community by factors that reduce ground cover.

The Fort Valley, Wing Mountain, and Taylor Woods plots of the Fort Valley Experimental Forest are near the mesic limit of this phase on soils of igneous origin. Much of the Beaver Creek area is near the xeric limit of the phase. The Long Valley Experimental Forest is also located in this phase at its mesic border with the ponderosa pine/screwleaf muhly-Arizona fescue HT but, in contrast, is on limestone-derived soils. Timber volumes of ponderosa pine at Long Valley are some of the highest in the Southwest—35,000 board feet per acre (Schubert 1974).

Vegetation

Ponderosa pine has a mean basal area of 91.3 square feet per acre (20.9 m^2 per ha), and stand reproduction averaged 118 stems per acre (292 per ha). Arizona fescue is the dominant herbaceous species on the basis of foliar cover, averaging 13% cover, with maximum values of 65%. Both buckbrush (*Ceanothus fendleri*) and mountain muhly are very common. Mountain muhly has broader limits of environmental tolerance than Arizona fescue and is less predictable in its occurrence, thus limiting its utility as an indicator species.

Discussion

Mistletoe was present in moderate to heavy amounts. The Arizona fescue phase is relatively well suited to both logging and grazing. It occurs on some of the most accessible terrain and, as a result, has been overexploited.

Areas which are heavily grazed in spring show increased levels of mountain muhly, reduced levels of Arizona fescue, and invasion by blue grama, broom snakeweed (*Gutierrezia sarothrae*), pingue (*Hymenoxys richardsonii*), and a wide variety of forbs (Arnold 1950). Areas grazed by sheep, particularly in summer and autumn, have dense Arizona fescue stands and an absence of mountain muhly and forbs, although pingue is more abundant. Heavy soils on moist sites that are heavily disturbed tend to revert to minute muhly (*Muhlenbergia minutissima*). In contrast, lighter soils on drier sites tend to revert to cheatgrass (*Bromus tectorum*). Arizona fescue has nearly been eliminated in places by extreme and persistent misuse (Leiberg et al. 1904), followed by subsequent encroachment of dense ponderosa pine stands. Many low-lying meadows which tend to hold water in early spring still have not regenerated to pine, even though they were logged about 100 years ago. These microsites often contain abundant spike muhly (*Muhlenbergia wrightii*). Whether spike muhly was abundant before the logging is unknown. Incomplete site preparation may reduce natural regeneration of pine, because chemical exudates from fescue inhibit germination and early growth of seedlings (Rietveld 1975). Other sites, such as Garland Prairie, developed dense fescue stands and resisted pine reestablishment for as long as 100 years. Buckbrush tends to increase in this and other moderately wet habitat types after fire. Intensive grazing by livestock or wildlife soon after germination will greatly reduce the number of buckbrush seedlings. Deliberate management, both for trees and for livestock, is required to maintain this phase in a productive state.

b. *Quercus gambelii* phase (ponderosa pine/Arizona fescue HT, Gambel oak P)

Distribution

The Gambel oak phase (fig. 8) is found in the same physical situations as the Arizona fescue phase of the habitat type, except Gambel oak tends to occur more on rock outcrops and slopes. The phase is sometimes

Figure 8.—Ponderosa pine/Arizona fescue HT, Gambel oak P (plot 288), Janice Tank north of Blue Ridge, Coconino National Forest, 6,860 feet (2,091 m) elevation. This phase occurs on rockier sites and usually has lower productivity than the Arizona fescue phase.

found on small (0.25 to 1 acre; 0.10 to 0.41 ha) inclusions of rocky areas within a general area supporting the Arizona fescue phase.

Vegetation

Vegetation of the Gambel oak phase is dominated by ponderosa pine, which averages 79 square feet of basal area per acre (18.1 m^2 per ha). Ponderosa pine reproduction averaged 56 stems per acre (138 per ha). Gambel oak is common as a tree and averages 5% cover as a shrub. Arizona fescue averages 5% cover with maximum values of 40%. Mountain muhly is common.

Discussion

The Gambel oak phase is a persistent, late successional community which is similar in origin and interpretation to the Gambel oak phases of the ponderosa pine/screwleaf muhly and ponderosa pine/screwleaf muhly-Arizona fescue habitat types. It is in contact with the same habitat types as the Arizona fescue phase.

Mistletoe conditions in the Gambel oak phase are similar to those in the Arizona fescue phase of this habitat type. It is not as well suited for grazing as the Arizona fescue phase because of reduced forage production and the presence of oak thickets. Timber production and potential is also less in this phase. The Gambel oak phase is probably very important to wildlife, particularly when it occurs as islands surrounded by the Arizona fescue phase.

c. *Bouteloua gracilis* phase (ponderosa pine/ Arizona fescue HT, blue grama P)

Distribution

This phase (fig. 9) occurs in the Coconino and south Kaibab National Forests, with scattered stands on the western side of the Apache-Sitgreaves. Stands range in elevation from 5,400 feet (1,650 m) on plateau areas removed from the Mogollon Rim to 8,700 feet (2,560 m) on the southeastern flanks of the mountainous areas

Figure 9.—Ponderosa pine/Arizona fescue HT, blue grama P (plot 275), Government Prairie, Kaibab National Forest, 7,300 feet (2,225 m) elevation. This area typifies ponderosa pine regeneration problems.

near Flagstaff and Williams, Ariz. More than 80% of the sites occurred on gentle slopes or flat areas. This phase is found on drier sites than the other two phases of the habitat type.

The blue grama phase contacts the ponderosa pine/screwleaf muhly-Arizona fescue habitat type in very moist situations and the other two phases of the ponderosa pine/Arizona fescue HT in intermediate situations. It also adjoins the ponderosa pine/blue grama HT—primarily the Gambel oak and pinyon (*Pinus edulis*) phases—in drier areas, such as southwestern exposures. Basalt and cinder parent materials and thin soils, primarily the Brolliar and Sponseller series, are typical of the blue grama phase.

Vegetation

Arizona fescue and blue grama are the dominant herbaceous species, averaging 9% and 3% coverage, respectively. Gambel oak occurs sporadically, but is rarely important in these stands. Ponderosa pine has a mean basal area of 50 square feet per acre (11.5 m^2 per ha) and only 31 stems per acre (77 per ha) of regeneration.

Discussion

In the absence of disturbance, Arizona fescue is the dominant grass species. However, these sites are dry enough that blue grama would be expected in a mature community. Given any significant disturbance, Arizona fescue will decrease and blue grama will increase. Therefore, this represents a climax phase which is relatively fragile and likely to undergo regression into drier types under conditions of overuse.

Mistletoe occurred in moderate to heavy amounts in this phase. Ponderosa pine reproduction is similar to that in the Arizona fescue phase, but the blue grama phase may be subjected to severe spring drought. Low and wet areas, which tend to form frost pockets and exhibit poor soil aeration, and areas with high densities of Arizona fescue are extremely difficult to regenerate naturally with ponderosa pine.

Much of the area southeast of Williams, Ariz., characterized by ragweed (*Ambrosia psilostachya*) and other forbs, belongs to this phase. Soil damage may have occurred on those sites in the past, and recovery may require cultural treatments or management practices that increase desirable ground-cover densities.

4. *Pinus ponderosa/Bouteloua gracilis* (ponderosa pine/blue grama) habitat type

This is the driest ponderosa pine habitat type in northern Arizona. Variation within the habitat type can be partitioned into five phases: *Bouteloua gracilis*, *Pinus edulis*, *Quercus gambelii*, *Andropogon hallii*, and *Artemesia tridentata*. The habitat type is characterized by open, low density stands with lower plant basal area and coverage and more exposed soil surfaces than other habitat types.

a. *Bouteloua gracilis* phase (ponderosa pine/blue grama HT, blue grama P)

Distribution

This phase (fig. 10) occurs most commonly in the southern portions of the Kaibab and northern areas of the Coconino National Forests and is absent in the northern part of the Kaibab National Forest and the New Mexico portion of the Apache-Sitgreaves National Forest. It ranges in elevation from 6,600 to 7,200 feet (2,010 to 2,190 m) on plateaus and mesas. Basalt is the typical parent material supporting Brolliar and Sponseller soils.

The blue grama phase is a climax ponderosa pine association which occurs adjacent to pinyon-juniper forests in drier areas and the ponderosa pine/Arizona fescue habitat type in wetter stands.

Vegetation

Mean basal area of ponderosa pine was 35 square feet per acre (8.0 m^2 per ha), and stocking averaged 43 stems per acre (106 per ha). Blue grama is the diagnostic herbaceous species (mean cover 3%); screwleaf muhly and Arizona fescue are absent. Redroot eriogonum (*Eriogonum racemosum*) is common.

Discussion

Fire is not a major factor in this phase, except that ground fires may eliminate or reduce pinyon and juniper invasion in some areas. Mistletoe is light to moderate in this phase.

This is a dry phase, with the lowest potential timber production of any phase in ponderosa pine forests. Grazing potential is also low, because most range grasses are difficult to establish. Western wheatgrass (*Agropyron smithii*) and bottlebrush squirreltail are among the better adapted species. Some stands south of Williams, Ariz., have been devastated, with the her-

Figure 10.—Ponderosa pine/blue grama HT, blue grama P (plot 177), Kaibab Lake, Kaibab National Forest, 6,820 feet (2,079 m) elevation. This is a dry habitat type with low productivity.

baceous layer now dominated by ragweed. Where this is the situation, soil damage may have occurred, and recovery may be long and difficult in the absence of costly cultural treatment.

b. *Pinus edulis* phase (ponderosa pine/blue grama HT, pinyon P)

Distribution

This is one of the driest ponderosa pine types (fig. 11). It is found on basalt and limestone soils in the Coconino and southern portion of the Kaibab National Forests at elevations ranging from 6,300 to 7,100 feet (1,920 to 2,160 m). The phase occurs on at least four different soil series.

Transition areas between climax ponderosa pine and pinyon-juniper forests support this phase. It is climax, occurring at the lower limits of the ponderosa pine type.

Vegetation

Ponderosa pine has a basal area of 63 square feet per acre (14.5 m^2 per ha), and small size class pinyon is common. Ponderosa pine reproduction averaged 12 stems per acre (30 per ha). Blue grama averaged 7% cover and redroot eriogonum was common.

Discussion

Timber and forage productivity appear to be greater than in the blue grama and sand bluestem phases of this habitat type. Fires probably reduce the amount of pinyon and juniper, while logging may encourage the establishment or importance of these two species.

c. *Quercus gambelii* phase (ponderosa pine/blue grama HT, Gambel oak P)

Distribution

The Gambel oak phase of the ponderosa pine/blue grama HT (fig. 12) occurs in the southern part of the Kaibab, Coconino, and Apache-Sitgreaves National Forests at elevations ranging from 6,700 to 7,500 feet (2,040 to 2,290 m). It is found on rolling plateaus and gentle canyon side slopes underlain with limestone, sandstone, basalt, or cinder parent materials.

On drier sites, it abuts pinyon-juniper forest types, and on wetter areas, the ponderosa pine/Arizona fescue HT.

Vegetation

Ponderosa pine has a mean basal area of 57 square feet per acre (13.0 m^2 per ha). Ponderosa pine reproduction averaged 47 stems per acre (116 per ha). Gambel oak is a common tree and/or shrub. Blue grama averaged 2% cover.

Figure 11.—Ponderosa pine/blue grama HT, pinyon P (plot 130), Tufa Mountain, Coconino National Forest, 6,300 feet (1,920 m) elevation. This is one of the driest phases of the driest ponderosa pine type, forming a broad ecotone to the pinyon-juniper woodland.

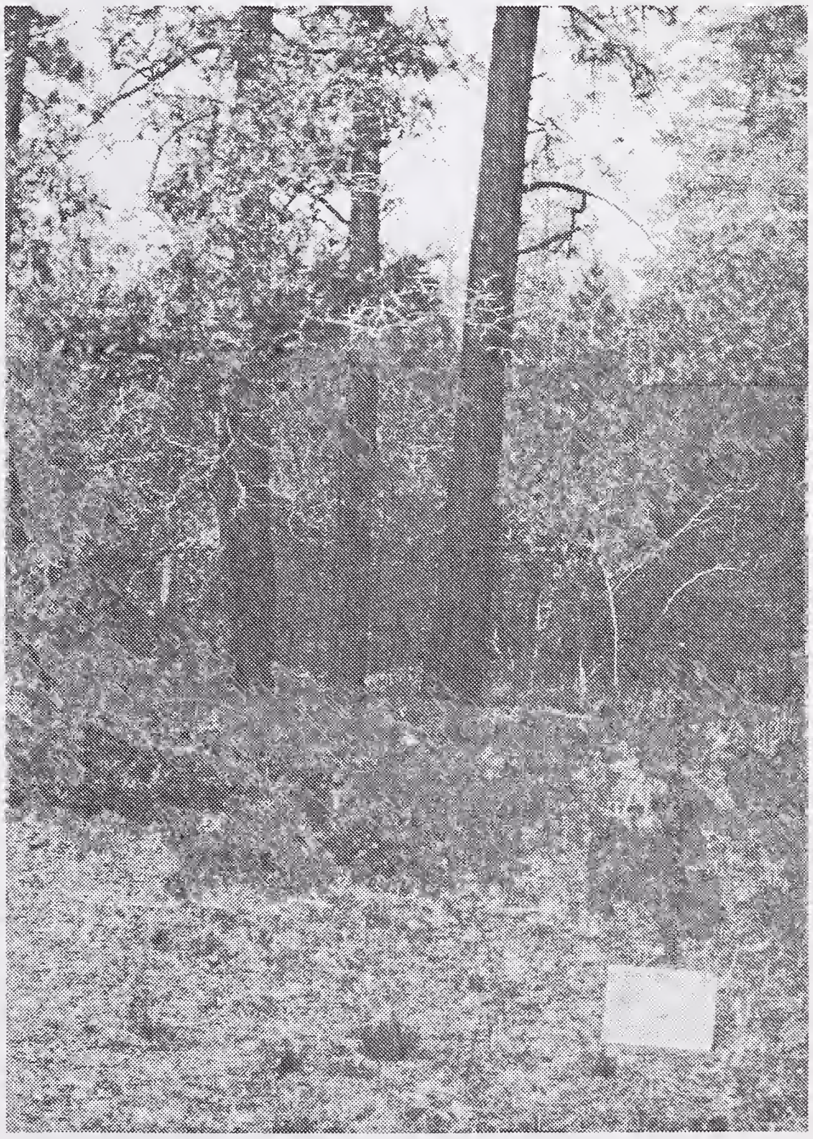

Figure 12.—Ponderosa pine/blue grama HT, Gambel oak P (plot 297), Scott Tank, Kaibab National Forest, 7,280 feet (2,834 m) elevation. This phase is wetter than the pinyon and big sagebrush phases of the same habitat type.

Discussion

This phase is at or near climax. Gambel oak would diminish slowly over time in most stands, resulting in increasing herbaceous coverage. Fires occur more frequently in this phase than in other phases of the habitat type. Recovery from old logging and grazing disturbance has been slow in these stands. It may be enhanced, however, by minimizing surface disturbances and utilizing range management practices that maintain ground cover adequate for soil protection. Mistletoe is light to moderate in this phase.

d. *Andropogon hallii* phase (ponderosa pine/blue grama HT, sand bluestem P)

Distribution

This is one of the most distinctive phases of any habitat type studied (fig. 13). It occurs only in the cinder cone area in the vicinity of Sunset Crater, near Flagstaff, Ariz. These stands are found on cinder ash parent material at elevations from 6,600 to 7,000 feet (2,010 to 2,130 m). The data indicate that more detailed study in this area may result in further subdivision of this phase and possible elevation of the phase to habitat type status.

The sand bluestem phase of the ponderosa pine/blue grama HT is a climax association that occurs adjacent to pinyon-juniper forests in drier areas. In wetter sites, it abuts the blue grama, pinyon, and Gambel oak phases of the habitat type.

Vegetation

Ponderosa pine has an average basal area of 38 square feet per acre (8.61 m² per ha). It has relatively normal diameter growth in these areas, but poor height growth. Ponderosa pine regeneration averaged 22 stems per acre (54 per ha). Sand bluestem occurs in 50% of the stands. It is absent in all other phases and habitat types except in the blue grama phase adjacent to the sand bluestem phase. Blue grama occurs in all stands, but is often present in small amounts (average cover 1%). Many areas have extremely low species diversity. Most of the ground surface in these stands is covered by pine litter and exposed cinders. Apache plume (*Fallugia paradoxa*) is common in the shrub layer in some stands which typically have higher species diversity.

Figure 13.—Ponderosa pine/blue grama HT, sand bluestem P (plot 131), Tufa Mountain, Coconino National Forest, 6,820 feet (2,079 m) elevation. This is a very scenic type with high wildlife value, low timber productivity, and fragile cinder soils.

Discussion

Fires tend to be unimportant because of sparse vegetation, and grazing is generally light because of lack of available water. Mistletoe incidence is also light. The soil surface is known to reach temperatures lethal to protein. Ponderosa pine reproduction usually occurs in the shade of a shrub, log, or other forms of cover offering protection from the direct rays of the sun, indicating a possible planting technique. Observations indicate that depressions in the soil may place plant seeds in closer proximity to moist soil layers and thus enhance germination and survival.

This phase appears to have limited value for timber or forage production. It is, however, strikingly scenic, with considerable recreational potential, as evidenced by the existence of Sunset Crater National Monument and the amount of off-road vehicle use. Also, shrubby hillsides receive heavy deer use in winter. Regardless of the kind of use made of the phase, the fragile and easily mixed soils may require greater than normal protection, because they are likely to be damaged by disturbance, especially by recreational vehicles or heavy equipment. If the less permeable layers are destroyed, water will quickly percolate below the root zone and trees and vegetative cover may be eliminated (Pearson 1950). Furthermore, plants are easily uprooted by trampling or vehicles and may require a long time for replacement.

e. *Artemisia tridentata* phase (ponderosa pine/blue grama HT, big sagebrush P)

Distribution

The big sagebrush (*Artemisia tridentata*) phase (fig. 14) occurs primarily on the south rim of the Grand Canyon and occasionally on the north rim at edges of ponderosa pine forests. The phase ranges in elevation from 6,300 to 7,400 feet (1,930 to 2,260 m) on limestone parent material. Areas for which soils had been mapped were in the Soldier-Hogg association.

Vegetation

Ponderosa pine has an average basal area of 52 square feet per acre (12.0 m² per ha). Ponderosa pine reproduction averaged 117 stems per acre (289 per ha). Big sagebrush is the dominant species in the shrub

Figure 14.—Ponderosa pine/blue grama HT, big sagebrush P (plot 159), Rowe Well, Kaibab National Forest, near South Rim, Grand Canyon, 6,640 feet (2,024 m) elevation. Influenced by Great Basin climate, this phase is probably better expressed in Utah.

layer, averaging 4% cover. Blue grama cover averaged 7%. Small pinyon trees are common, and redroot eriogonum is an important forb.

Discussion

Stands in Grand Canyon National Park that have not been grazed by livestock for more than 40 years still show the influence of heavy grazing. Mistletoe ranges from light to heavy. Evidence indicates that there is competition for forage between livestock and deer in this phase, partly because of depleted range conditions resulting from historical overuse from both classes of animals. Invasion by less valuable annual plants tends to occur in such areas where the soil surface has been disturbed and is especially prevalent after mechanical disturbance by equipment during timber harvesting operations. Western wheatgrass is adapted to these sites, however, and can be sown on disturbed areas. Seed must be sown on the loosened soil before rainfall, otherwise crust formation will prevent seed burial and subsequent establishment of grass.

This phase is probably common in Utah and could prove to be extensive. If so, it should be elevated to habitat type status.

COMMUNITY TYPE DESCRIPTIONS

1. *Pinus ponderosa/Poa longiligula* community type (ponderosa pine/longtongue mutton bluegrass CT)

This community is restricted to the north rim of the Grand Canyon, in the north Kaibab National Forest fig. 15). It ranges in elevation from 6,800 to 8,400 feet (2,070 to 2,560 m) on gentle canyon slopes of limestone parent material. Several steep, rocky sites supporting this community had high levels of Gambel oak as both a tree and a shrub.

The community is in contact with mixed conifer forests described by Moir and Ludwig (1979), which are dominated by white fir, Douglas-fir, quaking aspen (*Populus tremuloides*), and oregon grape (*Berberis repens*). On drier sites, the community is adjacent to the ponderosa pine/blue grama HT, big sagebrush phase, and to pinyon-juniper forests.

Ponderosa pine has a mean basal area of 80 square feet per acre (18.4 m^2 per ha), with 64 stems per acre (158 per ha) of reproduction. Longtongue mutton bluegrass averaged 4% cover. Oregon grape and groundsel (*Senecio multilobatus*) are very common in this community.

This community type is successional and has experienced exceptionally heavy grazing in the past (Rasmussen 1941). Herbaceous disturbance has been so great and so widespread that it is impossible to define the original climax community or the end point of the present succession. It is possible that Arizona fescue was once an element in the herbaceous layer of this community, because it occurs in some mixed conifer stands in the area (Merkle 1962, Rasmussen 1941,

Figure 15.—Ponderosa pine/longtongue mutton bluegrass CT (plot 258), Orderville Canyon, Kaibab National Forest, North Rim, Grand Canyon, 8,520 feet (2,597 m) elevation. Pinyon, blue grama, and big sagebrush may invade drier sites in this type after disturbance.

Moir and Ludwig 1979). Its absence in the ponderosa pine area is probably a result of excessive disturbance.

This community type is suitable for timber production. It is also important for wildlife, especially big game, because it constitutes the summer range for the Kaibab deer herd.

2. *Pinus ponderosa/Poa fendleriana* community type (ponderosa pine/mutton bluegrass CT)

This community occurs in the Coconino National Forest south of Flagstaff, Ariz., at elevations from 6,500 to 7,200 feet (1,980 to 2,190 m) (fig. 16). It is found on basalt, sandstone, and limestone parent materials. The soils are usually in the Brolliar or Soldier series.

Blue grama, Arizona fescue, and screwleaf muhly are absent in these stands. Mutton bluegrass is the dominant, averaging 2% cover. Ponderosa pine has an average basal area of 72 square feet per acre (16.5 m^2 per ha). Ponderosa pine reproduction averaged 177 stems per acre (289 per ha). Gambel oak is common as a tree and shrub. Mountain muhly is also common.

Some plots in this type were undisturbed relict areas and occurred on sites wetter than the ponderosa pine/Arizona fescue HT. Other plots were moderately to heavily disturbed, often on sites drier than the normal ponderosa pine/Arizona fescue HT. Because two different communities may exist, further study is needed. One is a moderately disturbed, fragile, transitional community between the ponderosa pine/blue grama HT and the ponderosa pine/Arizona fescue HT. The herbaceous layer is sparse and species diversity is relatively low. The community has been logged, burned, and grazed at moderate to heavy levels in the past. Perhaps Arizona fescue was once a minor component in this community and has disappeared because of disturbance. The community is found adjacent to the ponderosa pine/Arizona fescue HT, blue grama and Gambel oak phases, and the ponderosa pine/blue grama HT, blue grama, and Gambel oak phases.

Figure 16.—Ponderosa pine/mutton bluegrass CT (plot 125), Hog Hill, north of Turkey Tank, Coconino National Forest, 7,000 feet (2,134 m) elevation. This type produces little forage in a moderate rainfall zone.

The other community is a wetter climax community which occurs between ponderosa pine/Arizona fescue and ponderosa pine/screwleaf muhly, Gambel oak phases in limited areas of the Coconino National Forest.

Observations indicated that this wetter community was characterized by fine-textured soils which often had been damaged by logging and grazing activities during wet periods (Schubert 1974). In general, soils near the Mogollon Rim in the Coconino and Kaibab National Forests showed evidence of damage of this nature. Soil compaction and overgrazing cause dramatic increases in minute muhly and various forbs. Good site preparation is necessary for successful seeding of grasses. Complete recovery under reduced livestock grazing pressure may take more than 100 years (Clary 1975).

3. *Pinus ponderosa/Arctostaphylos pungens* community type (ponderosa pine/pointleaf manzanita CT)

This community complex (fig. 17) contains late seral and/or climax stands which are more typical of areas below the Mogollon Rim escarpment. This ponderosa pine type burns frequently because of its chaparral influences, and assessment of its successional status is difficult and arbitrary. More intensive sampling will likely reveal several xeric ponderosa pine types that are transitional to pinyon-juniper and chaparral habitats.

The community occurs sporadically in the Apache-Sitgreaves and Coconino National Forests, near the Mogollon Rim, on basalt, sandstone, and alluvial parent materials. It ranges in elevation from 6,000 to 8,700 feet (1,830 to 2,650 m) on gentle to steep slopes, and occurs on several different soil series.

Soils are often coarse and likely to have poor moisture-holding capacity. This community is probably best viewed as a persistent, late seral community which burns often enough to prevent attainment of a climax state. It is found adjacent to the Gambel oak phases of the ponderosa pine/screwleaf muhly and ponderosa pine/screwleaf muhly-Arizona fescue HT's. Disturbance increases shrub and juniper components of this type.

Ponderosa pine has a mean basal area of 57 square feet per acre (13.1 m^2 per ha), with reproduction of 52 stems per acre (128 per ha). Gambel oak is common as a tree and a shrub. Pointleaf manzanita (*Arctostaphylos pungens*) is common, as are shrub liveoak (*Quercus turbinella*) and Arizona oak (*Q. arizonica*). In some areas, Pringle manzanita (*Arctostaphylos pringlei*) or greenleaf manzanita (*A. patula*) may also be components of this community. Screwleaf muhly is present in wetter stands, while in drier or disturbed stands, blue grama is common. Occurrence of mistletoe is heavy.

Figure 17.—Ponderosa pine/pointleaf manzanita CT (plot 233), Dagnal Hollow, Sitgreaves National Forest, 6,400 feet (1,951 m) elevation. This type is better expressed below the Mogollon Rim outside the study area.

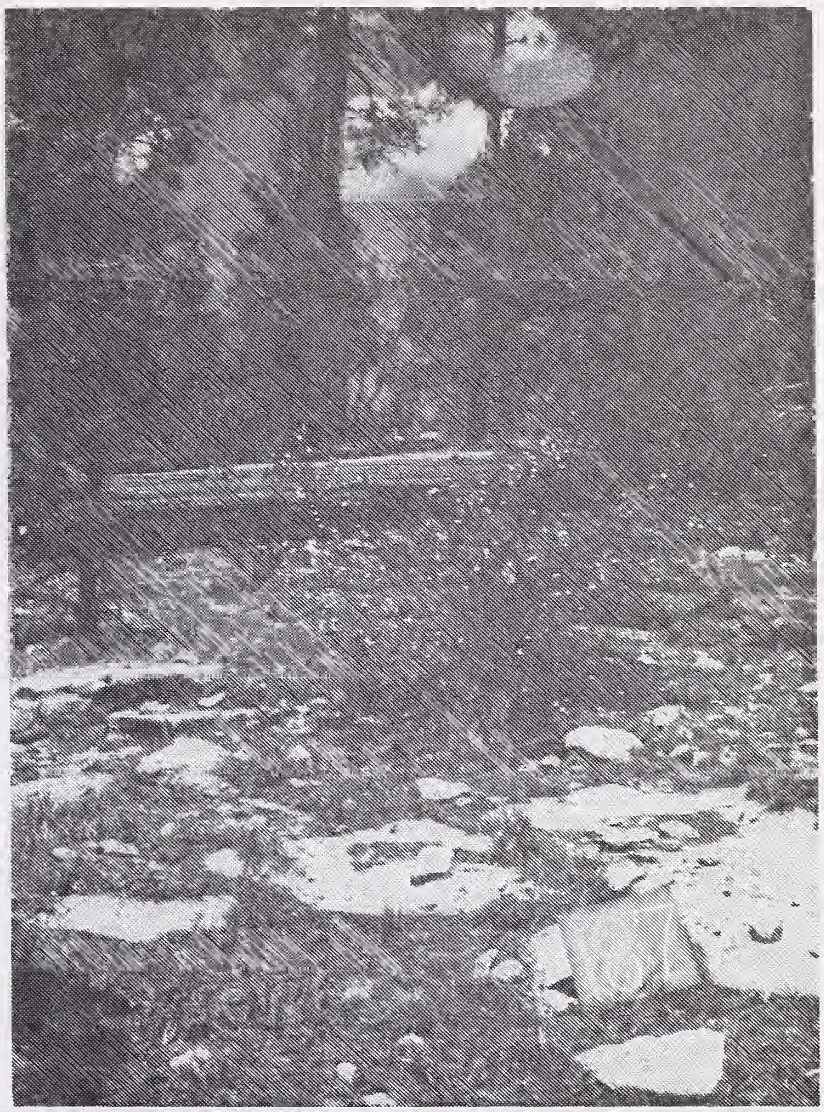

Figure 18.—Ponderosa pine/cliffrose CT (plot 187), near Heber, Ariz., Apache-Sitgreaves National Forest, 6,840 feet (2,085 m) elevation. This type is important for deer because it provides abundant browse on rough, rocky sites, often interspersed within other habitat types that are on gentler topography.

This type may occur in corridors of animals migrating below the Mogollon Rim in winter. More intensive sampling below the Mogollon Rim is required to fully describe and classify the variability of this community.

4. *Pinus ponderosa/Cowania mexicana* community type (ponderosa pine/cliffrose CT)[6]

The ponderosa pine/cliffrose community (fig. 18) was observed in areas west of Pinedale, Ariz. Ponderosa pine is the dominant tree, and cliffrose (*Cowania mexicana*) the dominant shrub, with blue grama and mountain muhly the dominant grasses. Both igneous and sedimentary parent materials support the cliffrose type. Plots containing some cliffrose occurred from 6,700 to 7,450 feet (2,044 to 2,272 m) elevation, but between 6,840 and 7,080 feet (2,086 and 2,159 m) elevation, plots contained at least 2% cliffrose cover. The type is limited to warm sites in ponderosa pine forests. It usually occurs in rough, rocky topography, which may reflect rooting or moisture requirements of cliffrose.

[6]Cowania stansburiana *is a commonly used synonym for* C. mexicana.

Stands which contained cliffrose varied greatly in associated vegetation and other characteristics. Further investigation of their position in an ecological classification is desirable.

The ponderosa pine/cliffrose type provides an important source of browse for herbivores. Because of the browse and associated rough topography, it is well adapted to support big-game animals. It is frequently interspersed on rocky areas in other habitat types and provides important variety for wildlife in these areas.

5. *Pinus ponderosa/Muhlenbergia virescens-Festuca arizonica-Bouteloua gracilis* community type (ponderosa pine/screwleaf muhly-Arizona fescue-blue grama CT)

The ponderosa pine/screwleaf muhly-Arizona fescue-blue grama CT (fig. 19) is a seral stage of the ponderosa pine/screwleaf muhly-Arizona fescue HT. The seral stage was found in the Apache-Sitgreaves National Forest near Springerville, Ariz., at elevations from 6,800 to 8,800 feet (2,070 to 2,680 m). Sites are

Figure 19.—Ponderosa pine/screwleaf muhly-Arizona fescue-blue grama CT (plot 102), Loco Knoll Tank, Apache National Forest, 8,520 feet (2,597 m) elevation. This is a seral type, with large numbers of forb species reminiscent of grazing disturbance.

relatively dry slopes and rolling plateaus on basalt and sandstone parent materials supporting several soil series.

The community occurs on drier ponderosa pine/screwleaf muhly-Arizona fescue HT's that have been disturbed by grazing and logging. The sites are successional and have more ubiquitous species characteristic of disturbance than the two phases of the habitat type. Stands contact the ponderosa pine/screwleaf muhly and ponderosa pine/screwleaf muhly-Arizona fescue HT's.

Ponderosa pine has a basal area of 65 square feet per acre (15.0 m^2 per ha). Ponderosa pine reproduction averaged 103 stems per acre (254 per ha) on these plots. Gambel oak occurs sporadically, but is rarely abundant, and alligator juniper (*Juniperus deppeana*) is common in small size classes. Pinyon seedlings occur in several stands. Screwleaf muhly, Arizona fescue, and blue grama are the dominant herbaceous species, averaging 7%, 5%, and 1% cover, respectively.

This community should slowly return to a ponderosa pine/screwleaf muhly-Arizona fescue HT under management practices that lessen disturbance and soil erosion, enabling the understory to recover. There is evidence that continued disturbance can cause invasion by pinyon and blue grama.

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APPENDIX

The data described below have been placed on deposit as supportive documentation which may be of interest to field personnel, managers, or other parties. The information is available from Timber Management Research, Rocky Mountain Forest and Range Experiment Station, Forestry Sciences Laboratory, Northern Arizona University, Flagstaff, AZ 86001.

1. Species encountered in the field sampling.
2. Soils associated with each forest community.
3. Mean percentage of plot surfaces covered by (a) exposed mineral soil, (b) rocks, (c) litter, (d) moss, and (e) vascular plant basal area summarized for each forest community.
4. Field forms containing information on the location, physical site factors, vegetation, and related observations for each of the 331 plots sampled.
5. Forest maps showing the location of each plot.
6. A computerized association table for each forest community. Each community is described on a plot by plot basis and then summarized using data on 10 species of trees, 11 species of shrubs, and 66 herbaceous species.
7. Computerized data base arranged by plot from 1 to 331.
8. Photographs of each plot, usually including closeup and distant scenes.

Table A1.—Ponderosa pine forest habitat types, phases, and community types of northern Arizona

Habitat type and phase	Abbreviation	No. plots
Pinus ponderosa/Muhlenbergia virescens HT	PIPO/MUVI HT	
Muhlenbergia virescens P	MUVI P	15
Quercus gambelii P	QUGA P	30
Pinus ponderosa/Muhlenbergia virescens-Festuca arizonica HT	PIPO/MUVI-FEAR HT	
Muhlenbergia virescens-Festuca arizonica P	MUVI-FEAR P	40
Quercus gambelii P	QUGA P	24
Pinus ponderosa/Festuca arizonica HT	PIPO/FEAR HT	
Festuca arizonica P	FEAR P	39
Quercus gambelii P	QUGA P	21
Bouteloua gracilis P	BOGR P	28
Pinus ponderosa/Bouteloua gracilis HT	PIPO/BOGR HT	
Bouteloua gracilis P	BOGR P	11
Pinus edulis P	PIED P	6
Quercus gambelii P	QUGA P	19
Andropogon hallii P	ANHA P	16
Artemisia tridentata P	ARTR P	13
Community Type		
Pinus ponderosa/Poa longiligula CT	PIPO/POLO CT	15
Pinus ponderosa/Poa fendleriana/ CT	PIPO/POFE CT	10
Pinus ponderosa/Arctostaphylos pungens CT	PIPO/ARPU CT	12
Pinus ponderosa/Cowania mexicana CT	PIPO/COME CT	4
Pinus ponderosa/Muhlenbergia virescens-Festuca arizonica-Bouteloua gracilis CT	PIPO/MUVI-FEAR-BOGR CT	9
Mixed conifer	—	17
Unclassified	—	2

Table A2.—Summary group association tables for selected species occurring in habitat types and community types[a]

		Habitat types						
		PIPO/MUVI HT,MUVI P	PIPO/MUVI HT,QUGA P	PIPO/MUVI ·FEAR HT MUVI·FEAR P	PIPO/MUVI ·FEAR HT QUGA P	PIPO/FEAR HT,FEAR P	PIPO/FEAR HT,QUGA P	PIPO/FEAR HT BOGR P
Trees	Size class							
Pinus ponderosa	< 4″ dbh	28/100	23/97	25/97	28/92	18/97	15/90	9/89
Pinus ponderosa	4-12″ dbh	6/73	6/83	5/77	9/75	4/74	10/71	6/75
Pinus ponderosa	>12″ dbh	5/100	6/100	6/100	5/100	5/100	5/100	4/96
Quercus gambelii	<4″ dbh	.	15/50	2/3	6/50	4/3	9/62	8/21
Quercus gambelii	4-12″ dbh	.	4/63	15/3	4/75	2/8	7/67	4/39
Quercus gambelii	>12″ dbh	.	3/33	.	2/46	2/3	1/62	3/36
Shrubs								
Artemesia tridentata		.	.	.	.	.	.	.
Berberis repens		.	2/7	0/8	0/4	1/10	0/5	0/11
Ceanothus fendleri		1/47	2/33	1/57	0/63	0/72	1/38	0/18
Quercus gambelii		0/33	5/90	0/25	1/100	0/28	5/90	3/57
Grasses								
Andropogon scoparius		0/20	0/13	2/13	0/13	2/23	0/14	2/36
Aristida arizonica		0/7	0/13	0/8	.	1/8	1/5	1/43
Aristida fendleriana		.	.	0/3	0/4	0/10	.	1/14
Blepharoneuron tricholepis		0/87	0/50	1/62	2/50	1/41	1/38	0/71
Bouteloua gracilis		.	0/3	.	.	.	.	3/100
Festuca arizonica		.	.	11/100	2/100	13/100	5/100	9/100
Koeleria cristata		2/73	1/70	2/58	2/54	0/38	0/57	4/57
Muhlenbergia montana		0/13	3/30	1/23	2/33	7/82	4/71	6/75
Muhlenbergia virescens		16/100	4/100	8/100	4/100	.	.	.
Poa fendleriana		2/93	3/97	3/70	2/83	3/74	2/95	3/89
Poa longiligula		1/7	9/10	0/8	1/20	0/3	2/14	.
Sitanion hystrix		2/93	2/97	2/87	1/92	2/100	3/100	3/100
Sporobolus interruptus		.	1/3	.	0/4	2/8	2/8	1/25
Forbs								
Achillea lanulosa		0/53	0/43	0/45	1/42	2/43	0/48	0.29
Antennaria parvifolia		0/40	0/43	0/40	0/33	0/33	0/43	0/25
Eriogonum alatum		.	0/3	.	.	0/3	0/5	0/4
Eriogonum racemosum		.	0/27	0/8	0/4	0/13	0/57	0/40
Fragaria ovalis		0/33	0/13	0/20	0/21	0/3	1/5	.
Hymenopappus mexicanus		0/33	0/7	0/23	0/12	0/18	.	0/7
Lathyrus arizonicus		.	9/17	0/13	1/17	0/15	0/10	.
Lithospermum multiflorum		0/13	0/36	0/27	0/33	0/38	0/19	2/21
Lotus wrightii		0/73	0/77	0/50	0/92	0/72	0/76	0/57
Pedicularis centranthera		0/47	0/27	0/15	0/50	0/23	0/23	0/14
Senecio wootonii		0/60	0/23	0/35	0/42	0/10	0/10	.
Solidago sparsiflora		0/27	2/36	0/35	0/42	0/38	0/52	1/18
Thalictrum fendleri		0/66	0/50	0/48	0/66	0/72	0/23	0/43
Vicia americana		0/13	0/40	0/38	0/45	0/41	0/62	0/32

Table A2.—Summary group association tables for selected species occurring in habitat types and communitytypes[a]—Continued.

		Habitat types					Community types				
		PIPO/BOGR HT,BOGR P	PIPO/BOGR HT,QUGA P	PIPO/BOGR HT,ANHA P	PIPO/BOGR HT,ARTR P	PIPO/BOGR HT,PIED P	PIPO/MUVI -FEAR-BOGR CT	PIPO/ARPU CT	PIPO/POLO CT	PIPO/POFE CT	PIPO/COME CT
Trees	Size class										
Pinus ponderosa	< 4″ dbh	11/100	13/84	7/81	23/77	5/89	22/89	13/92	14/73	33/100	4/75
Pinus ponderosa	4-12″ dbh	4/91	8/63	2/81	4/77	4/67	4/89	4/92	8/93	6/70	4/75
Pinus ponderosa	> 12″ dbh	2/91	4/95	2/100	3/100	5/78	5/100	3/92	7/100	4/90	4/100
Quercus gambelii	< 4″ dbh	.	6/58	.	6/15	2/27	7/11	37/67	.	14/80	.
Quercus gambelii	4-12″ dbh	1/9	5/79	.	11/15	4/33	2/33	4/75	13/20	3/90	2/25
Quercus gambelii	> 12″ dbh	.	3/11	.	.	.	1/44	3/25	.	1/60	3/25
Shrubs											
Artemesia tridentata		.	.	.	4/100	.	.	.	0/20	.	.
Berberis repens		1/9	0/16	.	1/15	1/11	0/11	.	1/60	1/30	0/25
Ceanothus fendleri		0/18	0/16	.	.	.	0/22	0/42	0/47	0/60	.
Quercus gambelii		0/45	1/90	.	3/62	2/67	0/44	8/100	0/27	2/100	0/50
Grasses											
Andropogon scoparius		3/18	4/11	0/31	0/8	1/33	2/33	0/17	.	1/30	0/75
Aristida arizonica		3/18	0/26	0/31	.	3/11	0/33	0/25	.	.	1/25
Aristida fendleriana		0/27	0/32	0/13	.	0/11	0/22	0/58	0/13	2/10	.
Blepharoneuron tricholepis		2/45	1/42	.	1/31	1/56	3/100	1/42	0/13	1/20	2/75
Bouteloua gracilis		3/100	2/100	1/94	7/100	7/100	1/100	2/75	0/20	.	4/100
Festuca arizonica		.	.	.	.	.	5/100	.	.	.	.
Koeleria cristata		0/73	1/84	.	2/77	1/67	4/100	1/58	0/40	0/80	0/75
Muhlenbergia montana		7/64	5/58	9/38	3/23	3/57	5/22	2/33	0/33	5/70	5/100
Muhlenbergia virescens		.	.	.	.	.	7/100	1/75	.	.	.
Poa fendleriana		5/100	4/100	1/19	4/100	4/78	2/78	2/75	1/93	2/100	3/75
Poa longiligula		1/9	0/5	.	0/15	.	.	.	4/100	.	.
Sitanion hystrix		3/100	4/100	1/69	1/92	3/100	3/100	3/92	2/80	1/100	3/100
Sporobolus interruptus		1/27	1/21	.	.	2/22	0/11	2/17	.	0/10	.
Forbs											
Achillea lanulosa		1/45	0/21	.	.	1/11	1/22	1/16	0/20	0/20	.
Antennaria parvifolia		0/54	0/31	.	1/46	.	0/22	0/16	.	0/30	.
Eriogonum alatum		0/27	0/21	0/6	0/15	0/44	0/44	0/41	0/7	.	0/50
Eriogonum racemosum		0/81	0/90	0/6	0/77	0/78	0/44	0/41	0/87	0/50	0/75
Fragaria ovalis		.	0/5	.	.	.	.	.	0/13	0/10	.
Hymenopappus mexicanus		.	.	.	.	.	0/22	0/8	0/13	.	.
Lathyrus arizonicus		.	.	.	.	.	.	0/8	.	27/30	.
Lithospermum multiflorum		.	3/21	.	0/7	0/11	0/33	0/16	0/27	0/10	0/25
Lotus wrightii		0/63	0/57	.	0/46	0/55	0/55	0/66	0/87	0/70	0/50
Pedicularis centranthera		.	0/31	.	.	.	0/33	0/25	0/27	0/70	.
Senecio wootonii		.	.	.	.	.	.	.	.	.	.
Solidago sparsiflora		2/18	0/52	0/6	0/38	1/33	0/11	0/16	0/73	0/80	0/50
Thalictrum fendleri		0/36	.	0/6	0/7	0/22	0/22	0/16	0/20	0/30	0/25
Vicia americana		1/9	0/15	.	.	.	.	0/8	1/13	0/70	.

[a]*Occurrence of each species in each habitat type, phase, and community type is indicated by two values separated by a slash. The first indicates the mean density/plot for the two tree species, or the mean coverage/plot for the shrubs, grasses, and forbs. In all cases, however, the first value is the mean for only the plots in which the species was present. The value to the right of the slash is the percent constance for each species in the phase or community type; it is the percentage of the total number of plots in the group in which the species was found. In cases where a species had less than 1% cover, a value of zero is used to the left of the slash. A dot indicates that the species was not found in a group.*

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Four major habitat types (HT's), divided into 12 phases, are described for the ponderosa pine forests of northern Arizona. In addition, five community types are described for the same area. On a wet to dry gradient, the HT's are (1) *Pinus ponderosa/ Muhlenbergia virescens*, (2) *Pinus ponderosa/Muhlenbergia virescens-Festuca arizonica*, (3) *Pinus ponderosa/Festuca arizonica*, and (4) *Pinus ponderosa/Bouteloua gracilis.*

Keywords: Forest vegetation, Arizona, habitat types, plant communities, forest ecology, and forest management

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U.S. Department of Agriculture
Forest Service

Rocky Mountain Forest and Range Experiment Station

Rocky Mountains

Southwest

Great Plains

The Rocky Mountain Station is one of eight regional experiment stations, plus the Forest Products Laboratory and the Washington Office Staff, that make up the Forest Service research organization.

RESEARCH FOCUS

Research programs at the Rocky Mountain Station are coordinated with area universities and with other institutions. Many studies are conducted on a cooperative basis to accelerate solutions to problems involving range, water, wildlife and fish habitat, human and community development, timber, recreation, protection, and multiresource evaluation.

RESEARCH LOCATIONS

Research Work Units of the Rocky Mountain Station are operated in cooperation with universities in the following cities:

Albuquerque, New Mexico
Flagstaff, Arizona
Fort Collins, Colorado*
Laramie, Wyoming
Lincoln, Nebraska
Rapid City, South Dakota
Tempe, Arizona

*Station Headquarters: 240 W. Prospect St., Fort Collins, CO 80526